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TUBERCULOSIS INFECTION AMONG YOUNG ADULTS ENLISTING IN THE UNITED STATES NAVY

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INFECTIOUS DISEASES

Tuberculosis infection among young adults enlisting in the United States Navy

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Background Tuberculosis (TB) is a re-emerging infectious disease threat worldwide. To protect the health and readiness of US military personnel, policies exist to screen for and treat latent TB infection at the time of service entrance. Results of this screening programme have not been recently described.

Methods Multivariate regression techniques were used to evaluate demographic and medical data associated with TB infection among all young adults entering US Navy enlisted service between 1 October 1997 and 30 September 1998.

Results A total of 44 128 adults (ages 17–35, 81% male) were screened for TB during this 12-month period. The prevalence of latent TB infection was 3.5%. Place of birth was very strongly associated with TB infection, with foreign-born recruits eight times more likely to have a reactive tuberculin skin test or history of infection. Those who reported their race as 'Asian/Pacific Island' had 3.8 times the odds of having evidence of TB infection compared with 'Caucasian' recruits, even after adjusting for place of birth.

Conclusions The prevalence of TB infection among Navy recruits was last reported as 2.5% nearly 10 years ago. The apparent increase to 3.5% in this large cohort is likely due to a concurrent increase in the number of foreign-born recruits, and it serves to underscore the importance of comprehensive screening and treatment of latent TB infections in this population.

Keywords Tuberculosis, PPD, tuberculin skin testing

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Tuberculosis (TB) has historically caused tremendous morbidity and mortality worldwide. Active disease rates in developed countries declined throughout the 19th and 20th centuries causing some to believe that TB was a disease of the past.[1–3] The resurgence of TB in the US in the late 1980s, along with the emergence of multi-drug resistant strains, refocussed attention on this challenging pathogen.[4–6] Although rates of active disease now are declining again in the US,[7] officials have continued to focus more energy on TB prevention programmes with the goal of eventually eliminating this public health threat. Screening for latent TB infections is a key component of most prevention efforts,[8] yet the prevalence of latent infections in large populations is rarely described.

The US military has been especially vigilant for TB infection since active disease not only impairs an individual's medical readiness, but can threaten large numbers of troops.[9,10] While military members may be at risk for acquiring TB infection because of their worldwide deployment, historically, their greater risk has been exposure to military members with active TB in the close-contact environments in which they live and work.[9–11] The US Navy mandates screening for latent TB infections by skin testing with five tuberculin units of purified protein derivative (PPD Tubersol®, Aventis Pasteur, Swiftwater, PA, USA), among all service members upon induction and periodically thereafter.[12] The results associated with the US Navy's TB screening programme may be valuable to both military and civilian public

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health professionals who are concerned about the dynamic epidemiology of TB.

Young adults enlisting in the Navy represent a healthy sample of the general US population. The prevalence of latent TB infection in this group was last reported among 2214 recruits enlisting during a 2-month period in 1990.[13] We evaluated the prevalence of TB infection among a much larger cohort who entered service during the 12-month period of fiscal year 1998. Since geographical risk factors for latent TB infection were last extensively reported more than 30 years ago,[14] current geographical and demographic risk factors are also described.

Materials and Methods

Population

We evaluated records of all adults who entered the US Navy's only recruit training facility, located in Great Lakes, Illinois, during fiscal year 1998 (1 October 1997 through 30 September 1998). Incoming recruits were asked about their history of TB. Those who could provide documented evidence of past TB infection, latent or active, were excluded from skin testing and referred for treatment if appropriate. Those with no known history or inadequate documentation of active or latent TB infection received tuberculin skin testing by the Mantoux method, with five tuberculin units of PPD (Tubersol®, Aventis Pasteur, Swiftwater, PA, USA), injected intradermally on the forearm. Technicians examined the test site 48–72 hours later for induration. Recruits with a skin induration ≥5 mm in diameter received further clinical evaluation including a chest radiograph.[12] Once active TB was ruled out, recruits were considered to have latent TB infection if they had (1) a tuberculin induration of ≥10 mm; (2) a tuberculin induration of 5–9 mm and radiographic evidence of old granulomatous disease, or known close contact to an active TB case; or (3) a documented history of past TB infection, precluding tuberculin skin testing. Health care providers followed established clinical practices for the evaluation, follow-up, and therapy for latent TB infection, in accordance with the Centers for Disease Control and Prevention guidelines.[12,15,16]

Data

Results of TB screening were obtained from the Preventive Medicine Division, Naval Hospital, Great Lakes. Most demographic variables (gender, age, race/ethnicity) were acquired from the Sailors' Health Inventory Program, a self-completed survey administered to recruits during their initial few days of training.[17] Place of birth was obtained from the Defense Manpower Data Center, Monterey Bay, CA, USA.

Place of birth, used to determine geographical risk factors, represents the state or country recorded as the birthplace of the recruit. For analysis, the primary categorization of place of birth was US-born or foreign-born, but to evaluate global and regional patterns, place of birth was further categorized by global region and region within the US. Age was categorized into approximate tertiles in the following manner: 17–18, 19–20, ≥21 years. Available race/ethnicity data classified recruits as Caucasian, African American, Hispanic, Asian/Pacific Island, and Other. For all independent variables, the category with lowest prevalence of TB infection was used as the reference group in all modelling.

Statistical analyses

We conducted three types of statistical analyses. First, we univariately compared potential risk factors with TB infection. Covariates with *P*-values ≤0.15 were included in subsequent analyses. Collinearity was assessed using regression diagnostics and cross products were introduced to test for significance of interaction. Next, we studied these same associations using a multivariable manual backward logistic regression process. For this model, recruits were classified as TB-infected or non-infected. Finally, we used manual backward polychotomous logistic regression to study five TB screening categories: not infected, 5–9 mm induration on skin testing with radiographic evidence of old granulomatous disease or known close contact with a TB case, 10–14 mm induration, ≥15 mm induration, and documented history of past TB infection. An alpha level of 0.05 was used for both logistic models as the criterion of inclusion in final models.

Prevalence was defined as the number of TB infections identified per 100 recruits. Odds ratios (OR) and 95% CI were computed using the Wald statistic for unconditional maximum likelihood estimation, both for the multivariable and polychotomous logistic models, to signify the risk of TB infection in this population.

Data management and all statistical analyses were performed using the SAS® system software (Version 8.0, Cary, NC, USA).

Results

During the study period, 44 128 men and women began recruit training. We captured complete data from 44 092 recruits; 36 had missing demographic data. Missing data analysis indicated that these recruits did not differ significantly from the study population and therefore were dropped from further modelling. The remaining 44 092 trainees were 19% female and ranged in age from 17 to 35 years (mean = 20, SD = 2.7). The majority of the recruits reported their race/ethnicity as Caucasian (55.3%), while 18.6% reported African American, 11.5% reported Hispanic, 5.0% reported Asian/Pacific Island, and 9.4% were categorized as 'Other' race/ethnicity. The population was composed of 90.6% US-born individuals and 9.4% foreign-born individuals. Within the US, 40.3% were born in the Northeast, 32.7% were born in the Southwest, 15.1% were born in the northwest, and the remaining 11.9% were born in the Southeast. Overall, few (0.7%) recruits had a known, documented history of TB infection. The majority (96.2%) of the population had a skin test induration size recorded as zero mm. All other measured induration diameters ranged from 3 to 95 mm (Figure 1), with preferential recordings at 10, 15, 20, and 25 mm.

The overall prevalence of latent TB infection was 3.5% (95% CI: 3.3–3.7) in this population (Table 1). Of the infected group, 0.6% (9) had a skin induration between 5 and 9 mm with radiographic evidence of old granulomatous disease, 27.4% (419) were of size 10–14 mm, 50.7% (776) were ≥15 mm, and 21.4% (327) had a known history of TB infection. Prevalence of infection was slightly higher in men than women and increased with age. Prevalence was highest among those who reported race/ethnicity as Asian/Pacific Island and Hispanic, and it was considerably higher in foreign-born recruits. By region within the US, those born in the Southwest had the highest prevalence of TB infection. Those born in the Northwest had the lowest

Table 1 Prevalence and adjusted odds ratios (OR) for latent tuberculosis infection among Navy recruits identified between 1 October 1997 and 30 September 1998

Characteristic	No. in strata	No. infected[a]	OR[b] (95% CI)	Prevalence (95% CI)
Total	44 092	1531		3.5 (3.3–3.7)
Gender				
Female[c]	8396	253		3.0 (2.6–3.4)
Male	35 696	1278	1.2 (1.0–1.3)	3.6 (3.4–3.8)
Age (years)				
17–18[c]	17 743	352		2.0 (1.8–2.2)
19–20	15 562	494	1.5 (1.3–1.7)	3.2 (2.9–3.5)
≥21	10 787	685	2.3 (2.0–2.7)	6.4 (5.9–6.9)
Race/ethnicity				
White[c]	24 403	280		1.2 (1.1–1.3)
Black	8221	281	2.5 (2.1–2.9)	3.4 (3.0–3.8)
Hispanic	5092	347	2.9 (2.4–3.5)	6.8 (6.1–7.5)
Asian/Pacific Islander	2226	400	3.8 (3.2–4.7)	18.0 (16.4–19.6)
Other	4150	223	2.8 (2.3–3.4)	5.4 (4.7–6.1)
Place of birth (overall)				
US[c]	39 939	669		1.7 (1.6–1.8)
Foreign	4153	862	8.1 (7.1–9.2)	20.8 (19.6–22.0)
Place of birth (global)[d]				
North America[c]	39 992	671		1.7 (1.6–1.8)
Africa	256	86	14.8 (11.1–19.7)	33.6 (27.8–39.4)
Asia	557	122	6.2 (4.6–8.3)	21.9 (18.5–25.3)
Australia/South Pacific	97	15	4.2 (2.3–7.6)	15.5 (8.3–22.7)
Central America	647	142	10.0 (7.9–12.8)	21.9 (18.8–25.1)
Europe	467	46	6.6 (4.8–9.1)	9.9 (7.1–12.6)
Philippines	936	243	6.8 (5.2–8.9)	26.0 (23.2–28.8)
South America	273	63	10.5 (7.7–14.3)	23.1 (18.1–28.1)
West Indies	867	143	6.8 (5.5–8.3)	16.5 (14.0–19.0)
Place of birth (within US)[d]				
Northwest[c]	6027	66		1.1 (0.8–1.4)
Northeast	16 106	256	1.3 (1.0–1.7)	1.6 (1.4–1.8)
Southeast	4739	71	1.1 (0.7–1.5)	1.5 (1.2–1.8)
Southwest	13 067	276	1.5 (1.1–1.9)	2.1 (1.9–2.4)

[a] Infected individuals had one of the following: a tuberculin induration of ≥10 mm; a tuberculin induration of 5–9 mm and radiographic evidence of old granulomatous disease, or known close contact to an active TB case; or a documented history of past TB infection.

[b] Adjusted odds ratios from multivariable logistic regression model.

[c] Reference category.

[d] Place of birth was categorized regionally within the US and globally in two additional models. Results for the other covariates (gender, age, and race/ethnicity) were similar to those presented in the overall model.

recruits differently than US-born, the changing demographics of the military population underscore the importance of TB screening in the entire group.

It is reasonable to consider whether a past history of receiving Bacille Calmette-Guérin (BCG) vaccine could be responsible for the high rate of tuberculin skin test reactivity found in foreign-born Navy recruits. The BCG vaccine history may have been elicited by preventive medicine professionals caring for recruits, but because such history did not influence clinical decision-making it was not maintained in the recruit database. Without these data, BCG history could not be included in this analysis and this introduces an important limitation in interpreting these results. It is possible that some of the recruits considered TB-infected had skin test reactions because of past BCG vaccination. It may be important to note, however, that 70% of tuberculin reactions in foreign-born recruits were ≥15 mm induration, and therefore, were more likely to represent true TB infections than past BCG vaccination.[8,24]

Among US-born recruits, place of birth in the Southwest was marginally significant in the multivariable logistic model. One might hypothesize that this is due to Mexico's higher rate of TB and frequent migration across the US border for employment, commerce, health services and leisure.[25] However, place of birth among US-born recruits was not significantly associated with TB infection in the polychotomous model. It is interesting that the prevalence of latent TB infection appeared so homogenous state-to-state within the US, even within the well-represented southwestern border states. Unfortunately, data

infections, and re-screening service members at regular intervals during their careers.[12] Further studies would be helpful in defining how compliant Navy service members are in re-screening and completing treatment of latent TB infections. Recently, a US Navy ship's crew member, who had not had regular TB screening, developed active disease while deployed, causing nearly 700 new latent infections and 17 new active cases of TB among his shipmates.[10] The unfortunate experience of this Navy ship highlights the importance of compliance with TB prevention programmes after recruit training.

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